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[09/16/2005] Some pages from the history of the creation of thermonuclear weapons in the USSR

Yu.A. Trutnev, First Deputy Scientific Director of RFNC-VNIIEF, Academician of the Russian Academy of Sciences

In this article I will outline a number of features and interesting points from the history of the creation and development of thermonuclear weapons in the USSR, in which I had the opportunity to take a direct part. I will consider only the period of time that relates to the first stages of the development of our country's thermonuclear program. I want to emphasize that this was the most important period, the importance of which cannot be overestimated, since it was at this time that fundamental physical ideas were put forward and the first fundamental steps were taken to implement them, which laid the foundation for our thermonuclear weapons.

Creation of RDS-37

Initially in the period 1952–1953. I worked for D.A. Frank-Kamenetsky and studied physical issues related to the possibility of detonation of deuterium in cylindrical systems. After that, I was involved in research related to the possibility of creating a two-stage thermonuclear charge. Research into the energy processes of a nuclear explosion of primary sources (nuclear charges) was of fundamental importance. The peculiarity of the circuits of some of these charges was that the level of energy release realized in them was sufficient for the main part of the energy of a nuclear explosion to come out of the central region containing fissile materials in the form of X-rays and spread through the products of the explosion of chemical explosives. This feature of a nuclear explosion was studied back in 1947–1948. in the pioneering works of the group L.D. Landau.

At the first stages of my activity, I worked on the issues of energy release of nuclear charges and the release of radiation energy from them, and I had thoughts about using this energy to compress the secondary module.

To form the direction of energy transfer, according to the proposal of A.D. Sakharov, the primary and secondary modules were enclosed in a single shell, which had good quality for reflecting X-ray radiation, and measures were provided inside the charge to facilitate the transfer of X-ray radiation in the desired direction.

In the course of this work, I was able to propose a method for concentrating the energy of X-ray radiation in material pressure, which made it possible to effectively carry out radiation implosion.

These studies also led me to determine a method that made it possible to ensure a predictable configuration of channels for the transfer of X-ray radiation, which later found wide application in two-stage thermonuclear charges. An important direction of my research at this stage of work was the study of various modes and conditions of thermonuclear combustion of the secondary module and determination of its energy release.

Of fundamental importance for the success of the development of a two-stage thermonuclear charge were the work on creating a primary energy source, led by Ya.B. Zeldovich.

A significant role in the formation of the principle of radiation implosion was played by D.A. Frank-Kamenetsky, who at the end of 1954, together with A.D. Sakharov issued a report that analyzed many of the scientific aspects of the new principle and the possibilities of its application to create various types of thermonuclear charges.

This two-stage charge scheme contained all the characteristic features of using the principle of radiation implosion to compress the secondary module. In this case, the problem of ensuring spherically symmetric compression of the secondary module was radically solved, since the time of “symmetrization” of the energy around the secondary module was much less than the time of compression of this module.

This pioneering work required the solution of new physical and mathematical questions. One of the main problems was to develop methods for calculating the transfer of X-ray radiation in a two-stage charge configuration.

The first two-stage thermonuclear charge, designated RDS-37, was developed in 1955 and successfully tested on November 22, 1955. The energy release of the

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charge in the experiment was 1.6 Mt, and since for safety reasons at the Semipalatinsk test site the charge was tested at partial power, the predicted full-scale energy release of the charge was ~ 3 Mt. The energy release amplification factor in RDS-37 was about two orders of magnitude, the charge did not use tritium, the thermonuclear fuel was lithium deuteride, and the main fissile material was U-238. The creation of the RDS-37 charge was a breakthrough in solving the problem of thermonuclear weapons, and the charge itself was the prototype of all subsequent two-stage thermonuclear charges of the USSR.

A large team of theoretical physicists took part in the work on creating the RDS-37 charge. Together with Ya.B. Zeldovich and A.D. The Sakharovs managed to put forward fundamental proposals, the implementation of which largely determined the appearance of this charge. In my submission for the title of "Hero of Socialist Labor" A.D. Sakharov wrote that "in 1954, Trutnev was one of the co-authors of the most important invention, which determined the entire further course of work at the facility."

I will also cite the statements of Yu.B. Khariton and the performance of A.D. Sakharov, related to the history of the creation of RDS-37.

"The decisive contribution to the creation of a new charge design (RDS-37) was made here by A.D. Sakharov, Ya.B. Zeldovich, Yu.A. Trutnev" (Yu.B. Khariton, Yu.N. Smirnov "On some myths and legends around Soviet atomic and hydrogen projects" in the book "Man of the Century. Yu.B. Khariton", Moscow, Publishing House, 1999, p. 143).

Now, decades later, it has become clear that the RDS-37 was a godsend.

Creation of "product 49" - a prototype of modern Russian thermonuclear charges

After the creation of RDS-37, intensive work began on the development of a new principle and the creation of new thermonuclear charges. A powerful intellectual impulse arose, which at times acquired the character of feverish activity.

During the "thermonuclear race" of 1956–1958. (Nuclear tests ended on November 3, 1958, and the first moratorium on their conduct began) 59 nuclear tests were carried out in the USSR, which is 2.5 times higher than their number in the period 1949–1955. The total megatonnage of nuclear tests by the end of 1958 was 27 Mt, with 90% of it occurring between 1956 and 1958. To support the implementation of the thermonuclear weapons program, the Northern Test Site was created on the Novaya Zemlya Islands, where 29 nuclear tests with a total megatonnage of 20.7 Mt were conducted by the beginning of the moratorium.

Particular attention should be paid to the works of 1958. This year, a new type of thermonuclear charge, "product 49," was tested, which was the next step in the formation of a standard for thermonuclear charges (its development was completed in 1957, but testing on the SIP did not take place). The ideologists of this project and the developers of the physical charge circuit were Yu.N. Babaev and I. The peculiarity of the new charge was that, using the basic principles of the RDS-37, it was possible to:

• significantly reduce overall parameters due to a new bold solution to the problem of transfer of X-ray radiation, which determines implosion;

• simplify the layered structure of the secondary module, which turned out to be an extremely important practical decision.

According to the conditions of adaptation to specific carriers, "product 49" was developed in a smaller overall weight category compared to the RDS-37 charge, but its specific volumetric energy release turned out to be 2.4 times greater. The physical design of the charge turned out to be extremely successful; the charge was transferred to service and subsequently underwent modernization associated with the replacement of primary energy sources.

In 1958, together with Yu.N. The Babaevs managed to develop 4 thermonuclear charges, which were tested on the field in 7 full-scale tests, and all of them were successful. This work was practically implemented within 8 months of 1958. All of these charges used a new circuit, first introduced in Product 49. Their energy release ranged from 0.3 to 2.8 Mt.

In addition, in 1958, under my leadership M.V. Fedulov also developed the lightest thermonuclear charge at that time according to the "product 49" design, which was also successfully tested. Work on the miniaturization of thermonuclear weapons was new at that time, and it was met with a certain misunderstanding and resistance. However, our position was understood and appreciated by I.V. Kurchatov, who supported it, which decided the issue of testing this new thermonuclear charge in 1958.

Rice. 1. Two phases of the RDS-37 explosion on November 22, 1955

1961–1962. Creating the basis of the thermonuclear arsenal of the USSR

In the fall of 1958, the USSR entered into a joint moratorium on nuclear tests with the United States. Without touching on the political side of the issue, we note that for the USSR this was an unsuccessful decision in military-technical terms. By this time, the United States had conducted 196 nuclear tests and created a powerful thermonuclear arsenal, which included 7.5 thousand nuclear and thermonuclear charges. Its total megatonnage in 1958 was 17.3 Gt (!). During the moratorium in 1960, the number of warheads in the US nuclear arsenal increased to 18.6 thousand, and its total megatonnage was 20.5 Gt. These figures show that the required level of megatonnage had already been achieved, and that the capabilities of the US nuclear arsenal were being diversified by increasing its size.

The total number of types of US nuclear and thermonuclear charges developed before the moratorium and transferred into service (before or after the moratorium) can be estimated at 35–40, and the total volume of their production is estimated at 40 thousand units.

The USSR did not have anything like this. This was a period of unconditional US nuclear superiority, and it was in their interests to "freeze" this situation. By this time, the USSR had already created "product 49" and a number of other thermonuclear charges, but the necessary replication of thermonuclear charges into various size and mass categories had not yet been achieved. It was also necessary to solve the problem of creating "super-powerful" thermonuclear charges in order to to some extent counter the enormous superiority of the US thermonuclear arsenal. It was impossible to do this without nuclear tests, and a dangerous period of growth in the US nuclear capabilities began during the moratorium period, based on the introduction of a system of nuclear and thermonuclear charges that they had worked out by that time.

Rice. 2. Model of the RDS-37 in the VNIIEF nuclear weapons museum.

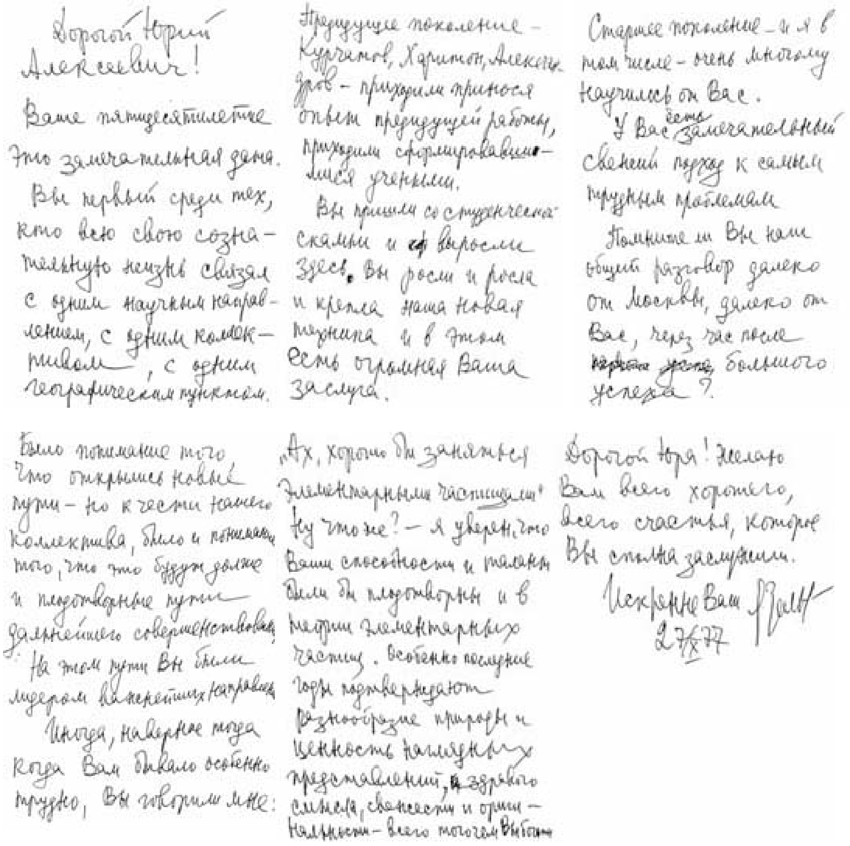
Our politicians talked about a nuclear-free world, about a complete ban on nuclear tests, and the USSR was surrounded by a network of US and NATO military bases, relying on which the US could actually destroy our state in a thermonuclear war. At the same time, we had practically no possibility of retaliating a significant threat to the American state.

Due to the deterioration of Soviet-American relations, on September 1, 1961, the moratorium on nuclear tests was interrupted, and the period of testing a new generation of thermonuclear charges of the USSR began. This period lasted only 16 months, but it was enough to practically create the basis of the thermonuclear arsenal of the USSR.

All developments 1961–1962. thermonuclear charges in Sarov were carried out under the leadership of A.D. Sakharova, Yu.A. Trutneva and Yu.N. Babaeva. Each development was usually supervised by one of these leaders, sometimes the leadership was carried out jointly. At the same time, I also happened to be an active developer of specific samples of thermonuclear charges.

During nuclear tests carried out with systems developed in Sarov, new thermonuclear charges were created with an energy release from 100 kt to 100 Mt. I note that out of 20 tests of thermonuclear charges in which I participated, 19 tests were successful. My co-authors on these developments were A.D. Sakharov, Yu.N. Babaev, V.B. Adamsky, V.G. Zagrafov, V.S. Lebedev, V.N. Mokhov, V.S. Pinaev, A.G. Rasskazov, Yu.N. Smirnov.

During this period of time, I had the opportunity to work closely with outstanding luminaries who laid the foundations for the development of our nuclear and thermonuclear weapons. I cannot help but note such a bright personality, personifying many of the virtues of a true theoretical physicist, as Ya.B. Zeldovich. Subsequently, when Yakov Borisovich had already left VNIIEF, I often had to meet with him, including at the Academy of Sciences. I will cite excerpts from one of his letters to me as a "document of the era" (Fig. 3).



Дорогой Юрий Алексеевич!

Ваше пятидесятилетие — это замечательная дата. Вы первый среди тех, кто всю свою сознательную жизнь связал с одним научным направлением, с одним коллективом, с одним географическим пунктом.

Предыдущие поколения — Курчатов, Харитон, Александров — приходили принося опыт предыдущей работы, приходили сформировавшимися учеными. Вы пришли со студенческой скамьи и выросли здесь. Вы росли и росла и крепла наша новая техника и в этом есть огромная Ваша заслуга.

Старшее поколение — и я в том числе — очень многому научилось от Вас. У Вас есть замечательный свежий подход к самым трудным проблемам. Помните ли Вы наш общий разговор далеко от Москвы, далеко от Вас, через час после ~~[illegible]~~ большого успеха?

Было понимание того что открылись новые пути — но к чести нашего коллектива, было и понимание того, что это будут долгие и плодотворные пути дальнейшего совершенствования. На этом пути Вы были лидером важнейших направлений. Иногда, наверное тогда когда Вам бывало особенно трудно, Вы говорили мне: „Ах, хорошо бы заняться элементарными частицами!" Ну что же? — я уверен, что Ваши способности и талант были бы плодотворны и в теории элементарных частиц. Особенно последние годы подтверждают разнообразие природы и ценность необычных представлений, а здравого смысла, свежести и оригинальности — всего [illegible]

Дорогой Юра! Желаю Вам всего хорошего, всего счастья, которое Вы столько заслужили.

Искренне Ваш [signature]
27/X 77

Rice. 3. Letter from Ya.B. Zeldovich Yu.A. Trutnev (October 1977)

Creation of a superbomb

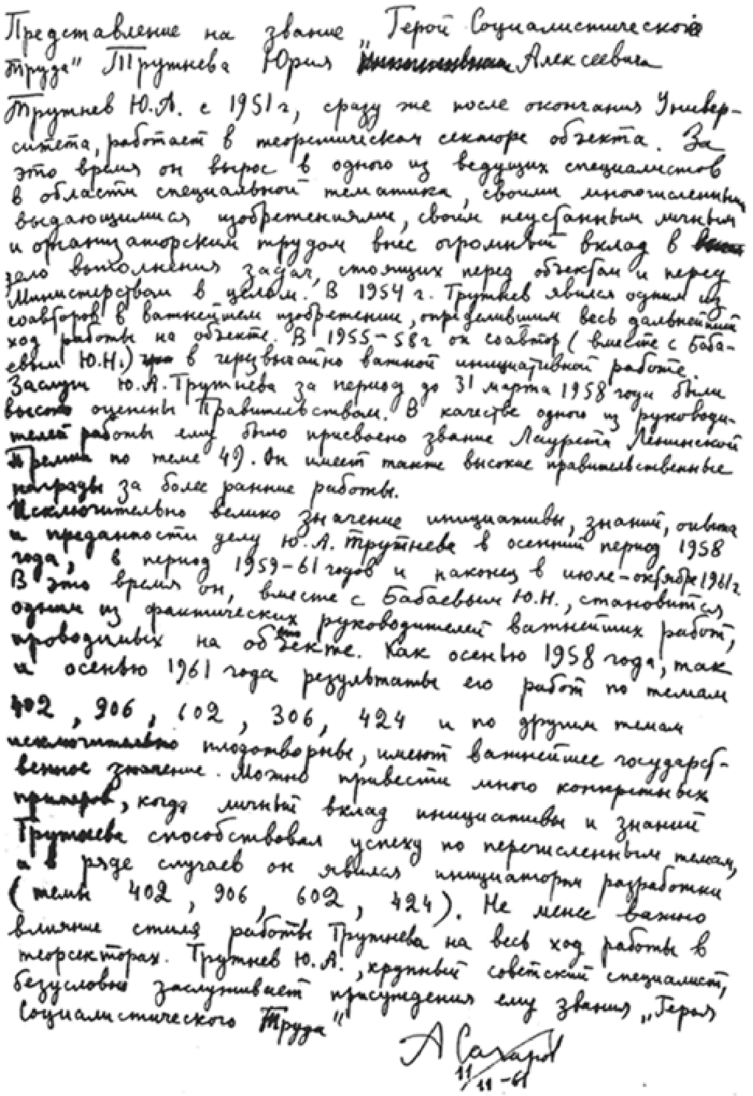
One of the well-known pages in the history of work on thermonuclear weapons of the USSR is the creation of a superbomb - the most powerful thermonuclear charge. I will dwell on some points of this development.

After the end of the moratorium in 1961, the development of this super-powerful charge was carried out in Sarov on my initiative and under the leadership of A.D. Sakharova, Yu.A. Trutneva and Yu.N. Babaeva; The team of authors also included V.B. Adamsky and Yu.N. Smirnov. Original solutions and accumulated experience made it possible to implement this development extremely quickly, and the charge was successfully tested on October 30, 1961.

Among the features of this charge, it should be noted that the large volume of the charge (due to its high energy release) required significant amounts of X-ray energy to carry out implosion. The developed nuclear charges did not satisfy this condition, and therefore, a previously developed two-stage thermonuclear charge with a relatively low energy release was used as the primary source of the "super-powerful charge". This charge was developed by me and Yu.N. Babaev.

Another feature of the super-powerful charge was related to the provision of full-scale tests. A full-scale test of a charge with E = 100 Mt would result in a significant yield of radioactivity, determined by the fission products of U-238. In addition, due to the specific conditions of the release of the aerial bomb in which the charge was located, the height of the explosion was insufficient to prevent the fireball of the explosion from touching the surface of the earth, and in this case significant radioactive contamination of the test site would have occurred. Therefore A.D. Sakharov proposed and practically implemented a partial-scale test of a superbomb, in the secondary module of which U-238 was replaced with passive materials that do not fission and are not significantly activated by thermonuclear neutrons. In addition, reducing the energy release level to 50 Mt made it possible to avoid the fireball of the explosion touching the ground. Thus, despite the enormous energy release, this test was carried out in a relatively environmentally friendly manner.

The creation and testing of the superbomb had great political significance, demonstrating that the USSR had solved the problem of achieving almost any level of megatonnage in its nuclear arsenal. It is interesting to note that after this the growth of the megatonnage of the US nuclear arsenal stopped.



Представление на звание „Герой Социалистического Труда" Трутнева Юрия Алексеевича

Трутнев Ю.А. с 1951 г., сразу же после окончания Университета, работает в теоретическом секторе объекта. За это время он вырос в одного из ведущих специалистов в области специальной тематики, своими многочисленными выдающимися изобретениями, своим неустанным личным и организаторским трудом внес огромный вклад в дело выполнения задач, стоящих перед объектом и перед Министерством в целом. В 1954 г. Трутнев явился одним из соавторов в важнейшем изобретении, определившим весь дальнейший ход работы на объекте. В 1955–58 г. он соавтор (вместе с Бабаевым Ю.Н.) в чрезвычайно важной инициативной работе. Заслуги Ю.А. Трутнева за период до 31 марта 1958 года были высоко оценены Правительством. В качестве одного из руководителей работы ему было присвоено звание Лауреата Ленинской Премии по теме 49. Он имеет также высокие правительственные награды за более ранние работы.

Исключительно велико значение инициативы, знаний, опыта и преданности делу Ю.А. Трутнева в осенний период 1958 года, в период 1959–61 годов и наконец в июле–октябре 1961 г. В это время он, вместе с Бабаевым Ю.Н., становится одним из фактических руководителей важнейших работ, проводившихся на объекте. Как осенью 1958 года, так и осенью 1961 года результаты его работ по темам 402, 906, 602, 306, 424 и по другим темам исключительно плодотворны, имеют важнейшее государственное значение. Можно привести много конкретных примеров, когда личный вклад инициативы и знаний Трутнева способствовал успеху по перечисленным темам, а в ряде случаев он являлся инициатором разработки (темы 402, 906, 602, 424). Не менее важно влияние стиля работы Трутнева на весь ход работы в теорсекторах. Трутнев Ю.А., крупный советский специалист, безусловно заслуживает присуждения ему звания „Героя Социалистического Труда"

А Сахаров
11/11-61

Rice. 4. Text of Yu.A.'s presentation. Trutnev to be awarded the title "Hero of Socialist Labor"

Solution to the problem of thermonuclear ignition

A feature of all thermonuclear charges under consideration was that the initial heating of thermonuclear fuel was carried out in them by the nuclear energy release of fissile materials. The importance of solving the problem of direct ignition of thermonuclear material due to its heating during the process of implosion was realized in the first stages of the implementation of the nuclear program.

After the advent of powerful laser systems, they also began to be used to solve this problem (known as LTS - laser thermonuclear fusion). However, here too it has not yet been possible to solve the problem of igniting thermonuclear material.

At the beginning of the program for creating thermonuclear charges, it was realized that it was important to solve at least part of this problem and ensure the ignition of thermonuclear fuel in the secondary module due to its implosion. In this case, the initial energy for implosion was provided by a nuclear explosion of fissile materials from the primary source. Optimism in solving this problem was due to the fact that in this case the energy for implosion was several orders of magnitude higher than the energy of implosion in a chemical explosion.

In 1958, at my suggestion, Sarov specialists joined in solving this problem. To test the thermonuclear ignition process, a special device ("Golden TIS") was developed, but due to the start of the moratorium, it was not possible to test it then. My co-authors in developing the physical design of this device were V.N. Mokhov, L.I. Ognev, V.S. Pinaev, V.P. Theodorites. In 1961, a more complex project attempted thermonuclear ignition, but was unsuccessful. Yu.N. participated in this development with me. Babaev and V.N. Mokhov. The reason for these failures was due to the insufficiently high degree of symmetry of the implosion of the central core of the thermonuclear fuel. In the next project (a return to the untested 1958 system) that I supervised, every effort was made to ensure near-perfect implosion symmetry. This brilliant work led to success, and in 1962, the problem of implementing thermonuclear ignition was solved in a special device. In other full-scale tests that followed, this success was consolidated, and as a result, thermonuclear ignition provided the calculated combustion of the secondary module with an energy release of 1 Mt. My co-authors in this development were

V.B. Adamsky, Yu.N. Babaev, V.G. Zagrafov and V.N. Mokhov.

The practical solution to the problem of thermonuclear ignition had extremely important consequences. This principle has found a variety of applications in the creation of fundamentally new types of thermonuclear charges, from special devices for the use of nuclear explosions for peaceful purposes to significant military applications.

Instead of conclusion,

I had the opportunity to participate in many large projects for the creation and development of nuclear and thermonuclear weapons in our country. However, the first decade of the thermonuclear program was, apparently, the most vibrant period in our weapons activities.

(Printed with abbreviations)

Magazine "Atomic Strategy" No. 18, August 2005

Re: Some pages from the history of the creation of thermonuclear weapons in the USSR (Total: 0)
from Guest on 07/13/2009

Thank you very much for the article, very interesting! Dmitriy.

[Reply to this]

Re: Some pages from the history of the creation of thermonuclear weapons in the USSR (Total: 0)
from Guest on 08/27/2009

[Reply to this]

Re: Some pages from the history of the creation of thermonuclear weapons in the USSR (Total: 0)
from Guest on 05/08/2022

Most interesting article, thank you!

[Reply to this]